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The Cleveland Convention Papers—IV

As is usual, much attention was paid to moulding sands, and of all the phases covered surely none is more important than the durability of various sands. The subject has not yet reached very far beyond the stage of obtaining basic data. Mr. Jack CoVan, working under the auspices of the A.F.A. Foundry Sand Research Committee's Sub-Committee on Durability, used five different types, made up of three synthetic and two naturally bonded ones. A repeated pour test was used and the indications are that synthetic sands have a longer life than naturally bonded ones.

The sintering tests which are being sponsored by the main committee have made material progress, and the recording of two points, designated A and B, has been wise for this work of establishing a standardised method of approach. There is obviously much more work to be done before foundry laboratories can be relied upon to report reproducible results, as the present system is undoubtedly somewhat delicate. The addition of 1 per cent. by weight to synthetic moulding sands of resin is reported by Mr. Emile Pragoff, junr., and Mr. C. P. Aldous to enhance the properties very materially. A subject somewhat akin was presented by Mr. Norman J. Dunbeck, who has recounted some large-scale experiments centred around the drying out of synthetic sands. "His approach to the solution of the drying-out problem is through the introduction into the sand mixture, by way of the tempering water, of treating agents designed to lower the vapour pressure of the water." The agents used included calcium chloride, lithium chloride, cereal binders, sulphite binders and sucrose. Several of these agents were efficacious, as but a small reduction in drying out is worth while. Fuel oil additions did not help in this direction, but are to be recommended on the grounds of increased workability.

Whenever reference is made in American foundry literature to sea coal, ground coal dust is meant. The retention of this old-fashioned name is just one more case of the curious conservatism accorded to the English language across the Atlantic. Thus "Sea Coal and Fuel Oil in Moulding Sand" is the title of an interesting Paper presented by Mr. Elmer C. Zirzow. His warnings against extravagant additions of coal dust are as important as his conclusions in favour of the use of controlled quantities. They include rat tails, cold shuts, misruns, dirt, drops and surface checks. For general purpose castings the author details in the second section dealing with fuel oil additions the following mixture:—35 shovels of system sand; 5 shovels of bank sand (grain size No. 100); 200 cub. in. of coal dust; and 5 quarts of fuel oil. Where fuel oil is used, the coal-dust additions should be reduced, the ratio standardised being 7.5 lbs. of coal dust to 1 lb. of fuel oil.

A Paper on the flowability of foundry sands by Mr. Erik O. Lissell and Eugene J. Ash does much to clarify the term "flowability," by differentiating between compression flow and true flow, the latter being the flow of the sand grains in directions other than that of the applied force. We believe that, with the majority of sands, there is much greater true flowability than is generally recognised, and later we may recall some apparently forgotten experiments made years ago.

A Paper of practical interest to the steel-foundry industry is by Mr. Fred B. Riggan, who covers the subject of "The Use of the Hot Strength Test as a Tool for Controlling Core Mixtures." The outstanding feature is that progressive additions from 1 to 5 per cent. of iron oxide raised the hot strength at 1,370 deg. C. from 4 to 200 lbs. The

(*Continued overleaf.*)

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BOOK REVIEW

The Personal Factor in Accidents. Issued by the Medical Research Council, Industrial Health Board, and published by H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 4d. net.

Whilst this Report constantly refers to the use of psychology in industry, it has taken no account of the reactions impinging on the reader through the reiteration of matter well known to industrial executives. The "meat" of this Report is contained in the section on accident proneness, but it has been so well watered down to the consistency of thin stew that its very bulk becomes indigestible. In plain English, the message of this booklet is that an accident record card should be kept for every employee, even though he or she has never sustained an accident or had a day's sickness leave. The reason is that it has been established that an employee sustaining a number of minor accidents is prone to incur major ones. All this is suggested because the same information, when contained in a book, present more work for a handful of statisticians! As there are many millions of workers in the country, the consumption of paper would not be inconsiderable. This Report is well below the level expected from, and usually attained by, the Industrial Health Board.

GRAPHITE IN PIG-IRON AND CAST-IRON

In "Metallwirtschaft," E. DIEPSCHLAG, dealing with the determination of graphite in pig-iron and cast iron, writes that, in the routine analysis of materials from different sources, considerable differences are frequently found in the graphite values. This may be due either to bad sampling and treatment of the samples or to errors in actual chemical analysis. Sampling errors are unavoidable where powdered samples of different materials with a different grain sizes and different specific gravities are being handled, and especially where the original material sampled is not of homogeneous composition. This applies particularly to the majority of pig-irons and cast irons. Errors in standard gravimetric determinations of graphite can only occur during the solution of the iron sample in nitric acid, since this acid is not only a strong solvent with the formation of nitrates, but is also a powerful oxidising agent. It dissolves iron and iron carbides, but not graphite.

If, in graphitic irons, carbon is precipitated on the decomposition of carbides during solidification and cooling and this carbon agglomerates, all intermediate stages being present simultaneously during the comparatively long time taken for solution, it is obvious that the solubility limits are not strictly defined and that some of the graphite may be oxidised by the acid. Systematic investigations carried out by the author reveal, in fact, that above a certain concentration the solvent action of nitric acid is different from that obtained with a weaker acid, and that part of the graphite is indeed oxidised. The degree of this oxidation is apparently associated with the total surface area of the graphite present. On this assumption and from the particle size of the graphite, the relative surface of the latter can be calculated, thus giving an indication of the physical nature of the graphite formed.

AMERICAN FINISHED STEEL DELIVERIES IN 1941

According to the American Iron and Steel Institute, finished total steel deliveries in 1941 were 62,484,000 net tons (2,000 lbs.), as compared with 45,850,825 tons in 1940. The leading consumer class was merchants and other distributors, accounting for 9,199,811 tons, or 14.7 per cent., against 6,686,534 tons in 1940. The construction industries took 8,127,889 tons, against 4,967,984 tons. The automotive and aircraft industries took 6,392,202 tons, or 10 per cent., as compared with 7,233,345 tons or 15.8 per cent. in 1940. Last year, shipbuilders received over 2,733,000 tons of steel, against 940,000 tons in 1940. Deliveries to the container industry last year amounted to 4,489,000 tons, against 2,985,338 tons; to the pressing, forming and stamping industry 6,321,536 tons, against 2,159,715 tons; to the railroad industry 5,680,800 tons, against 3,777,377 tons; to steel converting and processing industries 4,797,803 tons, against 2,928,842 tons; to machinery and tools 2,870,987 tons, against 1,885,408 tons; to the oil, natural gas and mining industries 1,985,140 tons, against 1,132,201 tons, and to the agricultural implement manufacturers 1,153,678 tons, against 919,502 tons. Miscellaneous industries and export took 8,731,492 tons, against 10,234,455 tons. Separate export figures are not published.

THE CLEVELAND CONVENTION PAPERS—IV

(*Concluded from previous page.*)

core mixture being 1,000 lbs., washed and dried, Ottawa A.F.A. fineness No. 50; 15 lbs. silica flour; 4 qts. bentonite; 6 qts. cereal binder; 20 qts. resin; and 2 qts. fuel oil. A Paper by Mr. R. F. Lincoln on "The Arrangement of Cores, Blowholes and Vents for Blowing Purposes" covers much the same ground as one we recently published as a Paper read before the South African Branch of the Institute of British Foundrymen, and is equally useful. Finally, Mr. D. F. Sawtelle, in a Paper "A Sand Control Programme in a Mechanised Malleable Foundry," relates further benefits that have accrued since he last reported on the initial conversion from hand methods. We confess that when we first scanned the batch of preprints for the Cleveland Convention we suspected a decline due to war conditions in the calibre of the Papers presented, possibly because of the few devoted to cast iron. On further study, we have completely changed that view, and now believe that the normal high standard of recent years has been exceeded.

PRACTICAL ECONOMIES IN THE USE OF COREBINDERS*

Survey of Materials Used—Core-powders—Rosin and Pitch—Oils—Paste Binders—Core Creams

By A. TIPPER, M.Sc.(Eng.).

The need for economy in the use of corebinding materials at the present time must be obvious to everyone. With a few exceptions all forms of vegetable drying and semi-drying oils, marine and fish oils, cereals and sugars, are needed for food or essential war purposes, whilst the bulk of them are imported from overseas. It is estimated that approximately 4,000 to 5,000 tons of such materials are used annually by foundries in this country for coremaking in normal circumstances, and probably considerably exceeded under present conditions. It is in the national interest to avoid waste or any unnecessary use of these valuable commodities.

Briefly it is suggested that economy can be achieved (1) by substituting natural bonded sand for oil sand: this is only practicable to a limited extent, and a number of objections to such a policy will occur to everyone; (2) by using lower proportions of corebinder than is normal practice: this calls for greater efficiency in general core making practice; (3) by more extensive use of permanent or semi-permanent cores: as, for example, in the light alloy and die casting industries, and (4) by the substitution of other materials as corebinders which may be in greater supply or of local origin (as, for example, by-products in extraction or refining processes), which could be used in place of imported materials.

Most of the following remarks will enlarge on methods of obtaining greatest efficiency in coremaking and obtaining maximum results from the materials in use, as well as suggesting possible alternatives. It is not intended to deal at any length with core sands, except to observe that the core sand is every bit as important as the binder in successful oil sand work.

General Survey of Materials Used

Before dealing with the various factors governing the efficient use of corebinders, it is as well to review briefly the characteristics of the materials which form the basis of the binders, core oils and compounds, since knowledge of the materials used is always a very great help in obtaining the best results from them. The individual materials in general use can be classified broadly into three groups, solids, viscous liquids and oils of various types (see Table I).

The principle solid binders include various types of dextrine and soluble starch produced from wheat, maize, potato, rice and tapioca starch by various chemical and heating processes. Dextrine has a normal moisture content of from 3 to 10 per cent., according to type and storage conditions, and picks up moisture from the atmosphere fairly readily. The mineral matter in dextrine is very

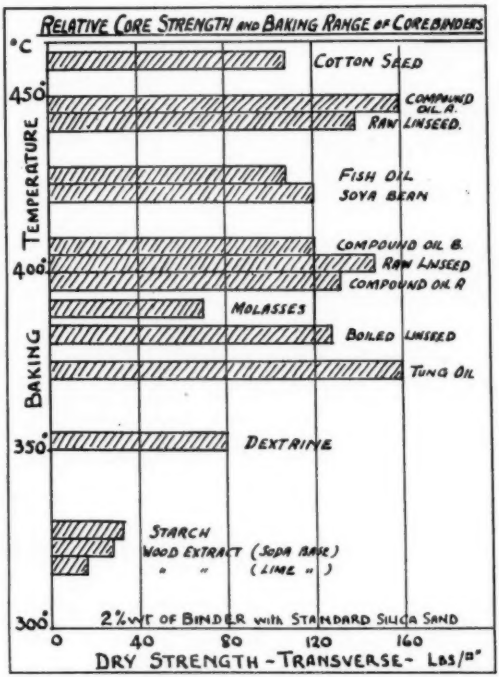

FIG. 1.—RELATIVE CORE STRENGTH AND BAKING RANGE OF COREBINDERS.

* A Paper read before the London Branch of the Institute of British Foundrymen, Mr. R. B. Templeton presiding.

Economy in Corebinders

small, but the solubility in water of different types varies considerably. Dextrine as a binder is very susceptible to small changes in moisture content of the sand, so that close control of moisture with all mixtures containing dextrine as a principal ingredient is essential. In the past, maize dextrine was most commonly used in this country, although potato dextrine and more recently tapioca, rice and wheat starches have all been used successfully where available. All these classes of material are of considerable food value, and the author believes that their use was largely discontinued in Germany well before this war, for economic reasons.

Corepowder

A different class of soluble starch, perhaps better known as corepowder, has come into prominence during the last 5 or 7 years. Produced largely from wheat starch which is treated to give a material with very high moisture absorption properties, it is not as soluble in the ordinary sense of the word as dextrine, but makes a very thick paste or jelly with cold water, and gives an appreciable green bond with undried silica sand containing, say, up to 4 per cent. moisture and not more than 2 per cent. by weight of corepowder. Small variations of moisture content do not affect the green bond of the mixed sand to the same extent as with dextrine, but in some foundries a proportion of dry silica sand is added to the

TABLE I.—*Classification of Materials Used as Corebinders.*

Class.	Name.	Type.	Characteristics.
Solids	Resin	Wood gum. Synthetic	V.G. Moisture resistance. Enhances dry strength value of thin oils—linseed, etc.
	Pitch	Mineral—petroleum coal Stearine.	Slight green strength. Dry strength with good moisture resistance when applied as solution.
	Dextrine	Maize Potato Tapioco, sago	Excellent green bond. Fairly good dry strength. Poor moisture resistance.
	Starch	Wheat, potato, rye	Good green bond, slight dry strength. Can be used with wet sand.
	Casein	Soluble or rennet	Little used. Good adhesive with air hardening and waterproofing properties.
	Sulphite lye	Soda base Lime ,,	Used mainly as green bond with oil sand or green and dry bond in weak sands. Water soluble.
	Mineral clays	Bentonites Colloidal clays Plastic fireclay	Replacing natural bond; also to impart strength at high temperature.
Viscous liquids	Molasses	First quality foundry type	Fairly good green bond. Good dry strength. Retards drying out of dextrine sand mixtures.
	Glucose	Water white or pale straw	Fairly good green bond. Good dry strength. Retards drying out of dextrine sand mixtures. Higher dry strength than molasses.
Liquids	Liquid resin	Water soluble thick resin oil	By-product. Low price. Fair bond and fairly good dry strength. Varies in character. Sticky.
	Sulphite lye	Conc.—1.30 sp. g. ,, —1.35 ,,	Similar to solid. Low baking temperature and readily burnt. Ash, 5—7 per cent.
	Rubber latex	—	Little use. Difficult to mix and unpleasant fumes.
Oils	Linseed	Raw oil Boiled oil	Highest dry strength. V.S. green bond. Good flowability. Air hardens on standing. Rapid baking.
	Soya	Raw oil; also Niger oil, etc.	Substitute for linseed. Does not bake as readily—no green bond. Very good dry strength.
	Fish oils	Herring. Seal. Red Oil. Cod.	Vary in character. Good dry strength and moisture resistance. Can be refined and deodorised for use in blended oils.
	Heavy fuel oil	0.85—0.96 sp. g. Petroleum base.	Requires high and prolonged stoving. Slight green bond is lost on heating. Good waterproofing. Used with linseed or other binders.
	Light mineral	Kerosene, spindle oil, etc.	Used as adulterant for seed oils and solvent for resin, etc

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undried sand to maintain the total moisture content of the mixed sand within certain limits.

Neither dextrine or starch imparts true moisture resistance to the dried core—*i.e.*, the core will soften under ordinary atmospheric conditions in the foundry by taking up moisture, and it is general practice to use a proportion of linseed oil, resin or other moisture-resisting agents in addition, if the core is to stand for any length of time and retain its strength. In general practice something like 2 per cent. by weight of dextrine or starch is usual, and it should not be necessary to exceed this figure, whilst the addition to this mixture of ½ per cent. by weight of good quality linseed oil will give excellent dry strength, using a clean silica sand.

Rosin and Pitch

Rosin and pitch are in many ways similar in their characteristics as corebinders. They impart only slight green strength with fair dry strength, but have excellent moisture resisting properties. Cores produced with these materials are very easily fettled, but mixing or distribution in sand is not easily accomplished unless the resin or pitch is dissolved in some carrying medium. Lime-treated rosin in finely powdered form, which does not adhere to form a solid mass on standing, is used in America for direct mixing in sand, and is now also available here. The most commonly used American type of wood resin is produced from shavings and pine roots by distillation. It is a bright reddish brown to yellow in colour, and is soluble in seed oils to the extent of about 25 to 27 per cent. This solubility is increased considerably by heating the oil, but on cooling and standing the rosin acids crystallise out, and only a limited amount will remain permanently in solution.

TABLE II.—*Oils Used as Corebinders.*

Type.	Name.	Iodine value.	Remarks.
Vegetable drying oils ..	Perilla	195—205	High price, resembles linseed.
	Linseed raw	175—195	Baltic variety has highest quality. Best-known core oil.
	„ boiled ..	140—170	Varies. Often adulterated. Rapid drying.
	Tung	160—170	Fastest drying oil known. Very high dry strength. High price.
	Soya bean	125—135	Substitute for linseed.
	Niger oil	130—140	„ „ Not in common use.
Semi-drying	Corn or maize ..	115—125	By-product, in restricted use.
	Cotton seed	105—115	High baking temperature required. Fair dry strength.
	Ground nut	100—110	Adulterant for linseed, etc.
Non-drying and greases..	Cocoanut	—	Gives slight green bond and a non-sticking mix.
	Resin oil	70—80	Seldom used alone. Cheap; some dry strength.
	Wool grease	—	Prevents stickiness and air drying in dextrine mixtures.
	Linseed grease ..	—	Cheap by-product. Low strength.
Fish oils	Menhaden	150—170	N. American fish oil. Good dry strength.
	Herring	120—170	Varies according to refinement.
	Cod, seal and liver oils	140—175	„ „ „ Good dry strength. Liable to contain stearines.
Mineral oils	Kerosene	Very small	Sp. G., 0.82. No dry strength. Solvent and adulterant.
	Spindle	„ „	Sp. G., 0.8—0.83. No dry strength. Solvent and adulterant.
	Fuel oil	„ „	Sp. G., 0.8—0.96. Seldom used alone. Dry strength. Fair and good moisture resistance.

Gum rosins of many varieties are produced from various classes of tree, being the exuded sap or gum collected from the live tree, and imported from France, Spain and the Indies. These are of at least equal value to the distilled wood resin for core making, and in some cases being more soluble can be used in greater proportion. Pitch or bitumen are only partially soluble in oils, and require considerable heating, and the addition of thinners to produce a reasonably fluid material.

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Economy in Corebinders

Because any green bond produced by such agents as resin and pitch is lost on heating the core, it is usual to add a proportion of natural bonded sand, or a clay or starch type binder to the mixture so as to produce sufficient stiffening of the core during baking.

Sulphite Lye

Powdered wood extract (or sulphite lye), as well as the concentrated liquid form, is available for use as a corebinder. It has a fair green strength, not as high as dextrine or starch with comparatively low dry strength, which varies somewhat according to type, the soda-base variety having a distinctly better dry-strength value than the lime-base type. The comparative dry-strength values of various corebinders, including wood extract, are set out in Fig. 1, which also indicates the approximate recommended baking temperature. The concentrated "lye" is used mainly for the improvement of moulding sands, and contains from 6 to 7 per cent. mineral ash. Its low baking temperature and cheapness are obvious reasons for its extended use as a corebinder.

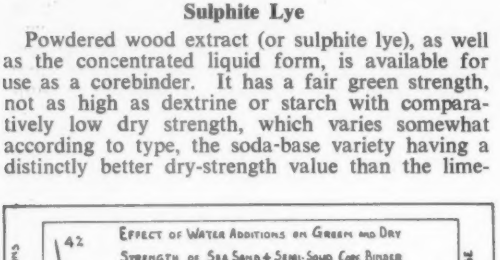

FIG. 2.—EFFECT OF WATER ADDITIONS ON GREEN AND DRY STRENGTH OF SEA SAND AND SEMI-SOLID COREBINDER.

Oils

Oils used as corebinders are listed in Table II, together with iodine values which, as well as indicating the drying power of the oil, give a good guide to the dry-strength value. Linseed oil is still the basis of most core oils. Both raw and boiled oil are used extensively, boiled oil particularly where its rapid drying properties are of service, though the raw oil gives distinctly higher dry strength. Linseed oil is one of the few materials in common use which will harden without artificial heating, and a mixture of silica sand with boiled linseed oil will toughen to produce a fair bond and plasticity on standing. Oils specially prepared with increased drying rates, such as the varnish or stand oils, will harden even faster, and a process of coremaking has been employed in some French steelfoundries using a mixture of hot silica sand, linseed oil and manganese dioxide. The large cores, after ramming up in the corebox, are left to self-harden and used without stoving.

Oils of the semi-drying oil class, used as substitutes for linseed oil, only oxidise and dry very slowly without the influence of heat. Some of the nut oils, soya bean oil and fish oils with low stearine content make good core oils, and all the principal oils tabulated will dissolve substances like rosin, pitch, bitumen and the metallic rosinate dryers, which are used to increase the drying rate and film strength. These oils will also form stable emulsions with other liquids and with water suspensions of dextrine, starch and other water-soluble binders, and the ease with which such mixtures can be emulsified has led to the common use of what are called core compounds (*i.e.*, mixtures of oil, water and some of the other bonding agents) which give a combination of properties. Each single bonding material has certain particular properties, such as high dry strength, or high green strength, or imparts flowability and ease of ramming, or rapid air hardening to produce self-supporting cores, etc., and by using certain combinations of the various binders it is possible to obtain a suitable oil-sand mixture to suit most requirements.

Paste Binders

The paste or semi-solid class of core compound consists principally of emulsified mixtures of dextrine, oil and water, sometimes with the addition of molasses or glucose in which the ratio of dextrine to oil is in the region of 4:1 and dextrine to water about 3:1. Such mixtures may also incorporate animal or vegetable fats as well as mixed oils, and produce a sand mixture possessing high green bond, the dextrine bond giving more or less self-supporting cores free from sagging or distortion when stripped from the corebox. The effect of moisture content of the sand on variation in green strength and dry strength of sand prepared with a semi-solid binder is shown in Fig. 2. Moisture resistance and dry strength of cores depend largely on the oil content of such binders,

though, as shown in the curves, dry strength is improved by an increase in moisture content up to about 1½ per cent. The practical top limit of moisture content is dictated both by the green bond required and by working properties (*i.e.*, stickiness) of the mixed sands.

Core Creams

The cream type of binder is an intermediate stage between pastes and thin oils. They consist of emulsions of oil, water and dextrine, flour, molasses or bentonite in varying proportions. The solids seldom exceed one-third by weight and with a colloidal substance such as bentonite, or when emulsifying agents are used, the proportion of liquids (oil + water), may be as high as 95 per cent., though in dextrine mixtures it seldom exceeds 70 per cent. in order to obtain some degree of bond and air-hardening properties. The creams mix more readily with sand than the paste binders, and in general give higher dry strength with lower green strength. They are particularly suitable for larger cores requiring slow baking or any type of core which can be split and dried in halves on flat plates.

Thin oils of the linseed class have already been mentioned, together with certain alternatives in the semi-drying class of seed oils which require higher drying temperature and a longer drying time to produce their best dry strength. Seed oils may be adulterated with fish oil, rosin oil, non-drying oils or mineral oil to as much as 50 per cent., in order to obtain a cheaper oil, and some of these mixed oils give very satisfactory dry-strength results when used under suitable conditions. Mineral oil and paraffin are often used to increase the spreading power of the vegetable oil and act as solvents for rosins, gums, bitumen or pitch. Provided that baking conditions are suitably adjusted, these blended oils can be used in most mixtures in place of the pure seed oil.

In general, these core oils impart little or no green bond to a sand, and can only be used alone with silica sand where shell driers are used or for simple flat cores. At the same time, under carefully controlled conditions, very economical mixtures can be used as in certain cases known to the writer, where mixtures containing only 1 per cent. or less by weight of oil are in use. Although innumerable mixtures have been evolved in the past to give a certain combination of properties, including good green and dry strength with easy baking, absence of irritating fumes during casting or a core which will not go back in the mould, but yet will collapse readily after casting, there is still plenty of opportunity for investigation and improvement.

Fundamental Principles

Factors which govern the most effective use of bonding materials will now be considered.

Mixing and distribution of the binder in the sand: This is an important stage in producing satisfactory oil-sand cores which is still neglected in many foundries, where it is not appreciated that an intelligent operator should be employed on the mixing of oil sand. Many troubles with cores in the foundry can be traced to carelessness in sand preparation, lack of attention to mixers and rough methods of measuring the additions. All charges of sand and binder should be measured or weighed to a reasonable degree of accuracy with some simple apparatus, *i.e.*, measures to hold the right quantity of liquid binder or powder and bottom discharge hoppers to hold a charge of sand and mounted so as to empty direct into the mixer.

Mixing time and speed depend largely on the type of mixer, but the following points should be watched:—(*a*) Regular cleaning and adjustment of the mixer; (*b*) cold sand should be used, particularly with dextrine mixtures, and heating up of the sand during mixing avoided as far as possible, since both may lead to premature drying out of the mixed sand, with consequent wastage and friable edges to cores; and (*c*) hard pellets or lumps of binder in the mixed sand, which sometimes occur when using the paste or semi-solid type of binder, can often be traced to the formation of a hard crust on the surface of the barrel or drum of binder when left exposed to the air in a warm place. Binders of this type should be stored in a cool place and, when in use, covered with a damp sack or sprinkled with water to keep the surface soft.

Poorly mixed sand leads to poor cores, waste of coremakers' time and possibly blown castings. Attention to the above points, with provision of adequate supplies of dry cold sand and baking of cores within a reasonable time of making them will be found well worth while. With molasses or wood extract mixtures, it is sometimes convenient to prolong the mixing or raise the temperature of the sand by friction and so cause slight drying out of the binder with considerable improvement in green bond of the sand.

(*To be continued.*)

YOUR WASTE PAPER—A FIRST LINE NEED

HIGH-STRENGTH PERMANENT MOULD IRON

Permanent mould iron castings are of a modified grey iron composition cast into permanent air-cooled or water-cooled metal moulds. The metal moulds are given coatings which prevent the castings from adhering to the mould and reduce the thermal shock when the molten metal strikes the mould. If applied in two layers, the original or base mould coating is a refractory clay on which is superimposed the second coating, which is graphite in the form of carbon smoke; some plants employ a single coating.

Some castings are produced in stationary moulds, while water pipe made by the De Lavaud process is cast centrifugally in rotating moulds. All permanent mould grey-iron castings are given a complete anneal. One such annealing treatment consists of heating to 857 deg. C. in 1½ hrs., holding at that temperature for ½ hr., and cooling slowly through the critical range in 1½ hrs. The microstructure after casting consists of lacy eutectiform graphite, ferrite, and a small amount of pearlite. No massive carbides are present. After the annealing treatment, the matrix is completely ferritic.

Most metallurgists would assume from this microstructure that the mechanical properties are low, in the order of magnitude of 8 tons per sq. in. in tensile strength. This misconception arises from the fact that when ordinary grey iron, sand cast, is given a full annealing treatment to a ferritic matrix, the tensile properties are in that range.

Results of Investigation

For instance, an investigation reported to the annual meeting of the American Society for Testing Materials by R. Schneidewind and E. C. Hoenicke, of the University of Michigan and Eaton Manufacturing Company, respectively, determined more of the properties of permanent mould irons which might be of assistance to designing engineers. These two investigators assembled data indicating that:—

(1) Permanent mould irons have a microstructure consisting of ferrite and graphite. Faint traces of eutectoid carbides are sometimes present.

(2) These irons, although possessing the structure noted above, are sensitive to section size, that is, the mechanical properties vary with section size.

(3) The smaller the section size, the finer is the pattern of eutectiform graphite. In large sections, the centre of the casting may contain some fine flake graphite.

(4) The Brinell hardness is about the same for all section sizes investigated, namely, 153 to 168. Permanent mould castings can be produced, with modifications in procedure, to a Brinell hardness of 190 or higher to 207 and yet have a microstructure of ferrite and graphite. For most applications, however, the softer and more machineable material is demanded and for this reason the investigation was conducted on castings representing a greater proportion of consumer tonnage.

(5) On sections varying 0.5 to 2 in. the tensile strength ranged between 23.3 to 10 tons per sq. in. The Brinell hardness, except for the 0.5-in. section (153), was fairly constant around 165. The analysis of the iron was approximately as follows: Gr, 3.41; C.C, 0.11; Si, 2.55; Mn, 1.01; S, 0.086; and P, 0.215 per cent.—"Iron Age" Report.

VACUUM-PRESSED BLAST-FURNACE REFRACTORIES

RAYMOND E. BIRCH, in a Paper to the U.S. Eastern States Blast Furnace and Coke Oven Association on "Blast-Furnace Refractories," refers to the development of the technique now known as vacuum pressing.

Referring to changes in manufacture the author states that the result of a change introduced in blast-furnace refractories cannot be fully measured in less than ten years. The first ten complete vacuum-pressed linings in U.S.A. were delivered in 1935 and 1936 and to date the only one which is out of service is a lining which was installed in a small merchant furnace. The remaining nine of the first ten vacuum-pressed linings are still in blast and had produced an average of about 1,600,000 tons of iron up to January, 1942. Several have passed the 2,000,000 mark and appear to be heading for new records. Thus, in contemplating further changes in blast-furnace refractories, it might be remembered that one has yet to measure the full effect of this change, which was probably the most important process change of the last two decades.

The first commercial application of vacuum pressing was developed specifically for and first applied to the manufacture of refractories for the blast furnace. Vacuum de-airing for repressed auger machine refractories was also applied first of all to blast-furnace brick. Both processes brought the brickmaker increased costs and difficulties all along the line, but they were introduced into the standard product, without an increase in price.

The need for vacuum pressing made itself evident when the plant operator found that he was baulked in trying to increase the toughness of blast-furnace brick by increasing the forming pressure. Air entrapped in the mould with the ground clay caused no trouble unless very high forming pressure was used; however, it then caused the brick to develop cracks as they came from the press. He then had no alternative except to reduce the forming pressure so that these cracks would not develop. At Ohio State University, where the commercial feasibility of auger machine de-airing was also first demonstrated, it was discovered that pressure cracks did not develop in power-pressed brick if vacuum was applied to the loose clay just before the brick were pressed. Thus if a means could be devised for withdrawing the air in the fraction of a second allowed by the normal pressing cycle, it would be possible to form the brick at a much higher pressure and to make them more serviceable. As a blast-furnace refractory problem, this was solved by Hendryx and his plan of flash evacuation was covered by U.S. Patent.

DIAGNOSING A CYLINDER COVER CASTING

IV.—PRACTICAL PRODUCTION PROBLEMS

by A. F. HAMMOND

Last contribution on the East Anglian Specimen Casting. Previous talks were reported in issues of July 23, August 13 and 20

First, the author wishes to thank both Mr. Slater and Mr. King for the interest they have taken and the splendid suggestions they have both put forward for making this casting. Mr. Slater tackled the problem with a view to machine moulding and certainly proved that he had made a good study of the job. Whether his method of running and risering would have produced a sound casting in the particular metal mixture which he advocated is open to question. As an added interest, and for the benefit of members, he (Mr. Hammond) had made a casting by Mr. Slater's method with his runners and risers, but used a special cylinder iron mixture.

The metal used was hot approximately 1,300 deg. C., and the runners (about which there has been much discussion) ran the job satisfactorily and the metal came up the risers. It took 25 secs. to cast. The casting was sectioned and it revealed the defect where expected, not to any great degree, but sufficient to suggest that it would not stand up to the test pressures specified. It would have been extremely interesting if Mr. Slater could have made a casting in his mixture and compared the results.

Mr. King had described an entirely different method, which he has adopted in his foundry, and with his mixture he has produced castings which, as far as can be seen, appear to be perfectly sound, and so suggest that the solution to this job is high-duty iron with, possibly, alloy additions.

However, the author has had the unpleasant experience of many of these castings appearing quite sound when sectioned, but for some reason when under the final tests they have failed. Although possessing considerable experience with this type of work, there is no wish to suggest that the method about to be described is the only one that will give entire satisfaction. However, an assurance is given that the foundry did, perhaps by good fortune, produce three perfectly sound castings in its cylinder iron mixture, which withstood the tests required, at the first attempt.

Characteristics of Casting

Undoubtedly in a casting of this type the problem set to the foundry is to beat the design, as a glance at the drawing will show that it does suffer from sectional changes and so does immediately set up at least two different rates of cooling and contraction. The foundry ideal, of course, is uniform sections, which are allowed to solidify progressively from the bottom upwards. With this problem an endeavour was made by the author to try and obtain as nearly as possible an even rate of cooling in all sections with the aid of chills or denseners. Chills or denseners are condemned in a good many foundries, but they can be used to great advantage with certain classes of work, not because permanent moulds are desired, but to obtain an equalisation of the rate of cooling of various sections. Sometimes they are used to eliminate a thin portion of sand core, which is subjected to excessive heat, from the sections of metal surrounding it, always of course bearing in mind the type of metal with which the chills are contacting so as not to become chilled, that is to say, converted into unmachinable white iron.

The casting, being a pressure-resisting casting used in a compressor, compressing hydrogen to a pressure of 900 lbs. per sq. in., it is imperative that the hydrogen must not leak into the water spaces, and the suction and delivery holes must not leak into one another. The final water test pressures in the valves and valve holes of 2,000 lbs. per sq. in. will soon show up any minor defect, or tendency towards open grain, which was not previously evident. These "pressure" castings demand a dense fine-grained structure in order to be serviceable. The structure of the iron, as, for instance, the amount of graphitic carbon present, and more important still the condition in which this graphite exists, is of paramount interest in castings subjected to pressures. The silicon and phosphorus contents are next in importance, since it is known high silicon tends to shrink less, but is more liable to drawing, and a high phosphorus content prolongs the solidification range with a similar effect. Internal defects and shrinkage are the most prolific sources of trouble in the foundry producing pressure castings.

The foundry where this particular casting is made has to run its cupolas, during a 2- to 3-hr. blow, to produce at least three different grades of

Diagnosing a Cylinder Cover Casting—IV

iron for many varying types, and sizes of jobs, and it will be appreciated that when a proportion of this work is pressure work, these conditions are not ideal.

Pattern and Core Boxes

It should be remembered that this job was required for three castings only, and would not be required for quantity production, so accordingly the job was put in hand as a one-off type of job. It does not present great difficulties for the pattern-maker, and the pattern was made from the solid block, allowing the moulder to make his own joint around a line shown on the pattern, leaving one facing H (Fig. 1) to be left loose and drawn in. The face O O in Fig. 1, where the spigot is made, being important and requiring to be clean, was accordingly made the bottom of the casting. This also gave advantage to the valve seats, which also have to be sound and clean.

Machinery allowances were fairly generous, and core prints were added to the pattern to support the denseners for the valves, valve holes, and the cone-shaped hole at the bottom. These are marked A, B, C, D and E. At the four corners where the holding down bosses are, core prints were added to the top and bottom of the pattern; these would support the water jacket core. The core prints A and B (Fig. 1) were made 3 in. long by $1\frac{1}{8}$ in. dia., and had to be worked loose on the pattern.

For the coreboxes, two half boxes for the water jacket were all that was necessary. These boxes were split through the centre line, as is indicated by section X X in Fig. 1. The four main openings left at the corners which give the support for this core are contained in these boxes, together with the water inlet hole marked "K." To do this, the block at each end of the box was split at these centre lines and kept in their correct position by iron dowels. The block which forms metal around the valves and valve holes was also worked from the joint of the box and dowelled. In deciding upon this way of making the corebox it was realised that this block had to be partly bedded in, but was preferred to having it a fixture on the bottom of the box and strickling the top face.

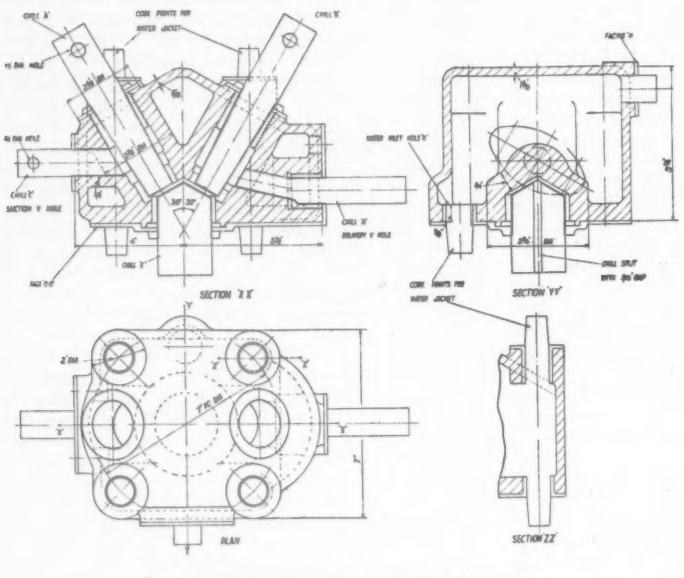

FIG. 1.—DRAWINGS OF SPECIMEN CASTING.

Moulding

The mould for this cover was of dry sand made in 12-in. by 12-in. box parts and, of course, stoved. It formed a two-part job, and the face O O (Fig. 1) was accordingly made the bottom of the casting, with a joint along the line marked on the pattern. By jointing down to the centres of suction and delivery holes (Fig. 2), it was possible to see both the denseners marked C, D in their correct positions when coming up. The downstick for the runner was placed at one of the corners, was $\frac{1}{4}$ in. in dia., and connected with the joint of the mould, where the sprue from it was cut to a point adjacent to a corner holding-down boss.

It was thought that to run this job, with all its internal denseners without any disturbances from them required bottom running at correct speed, with as hot a metal as possible, say in the region of 1,300 to 1,350 deg. C. These denseners would not be put in cold, but just luke-warm. One riser was thought to be necessary, and this was made

Diagnosing a Cylinder Cover Casting—IV

$\frac{1}{4}$ in. dia. and placed in a position which was marked on the pattern.

All this mould was freely vented, and densener E (Fig. 2) was gummed and placed into its correct position before stoving. It will be noticed that this densener was made in two pieces and had a gap of $\frac{5}{16}$ in. between each, which was made up with core sand.

The Core

The water-jacket core was made in halves in oil sand. Four pieces of $\frac{5}{16}$-in. rod bent to an L-shape and laid into one another, formed all the support at the four corner holes that was thought necessary. The core was also well vented, and provision was made for the gas to escape freely at these corners. The core was dried and then gummed together, and prepared ready for placing in its correct position in the mould.

As the face O O (Fig. 1) is at the bottom of the mould, provision had to be made for the securing of the two denseners A and B (Fig. 1) in the top part. This was done by drilling a $\frac{1}{2}$-in. hole near the end of the chill and a wire threaded through and so tied back to a piece of rod. These $\frac{1}{2}$-in. holes served a dual purpose, as they gave the means of inserting a rod so as to be able to knock the densener out after casting had been made. Coring up was commenced in the top half of the mould. The jacket core was placed in position first, the denseners A and B then put into position and tied back; then denseners C and D were placed in position. The moulder could then see into half of the mould and check the core and denseners in their correct positions and also examine the metal thicknesses. The bottom part was then closed over, making a touch on the four corners of the water-jacket core. The whole mould was then turned over. The next job was to ensure the vent holes in the corners of the water-jacket core were clear and free. A vent wire right through the top and bottom prints soon proved this. This forms one of the essential factors on closing a mould, as it is known that most cores give off gas when heated, as in the majority of cases all but the extremities of the cores are surrounded by fluid metal, and it follows that not only must the core be vented, but also that the gases generated in the core and collected in the vent must be drawn away through the mould or the box joint, whichever is the more convenient. This must happen freely and with as little restriction as possible. The jacket core in question, although not very large, in personal opinion needs well venting, due to the fact that it is practically surrounded by metal and some heavy sections, and seeing that the casting is made fairly quickly, any entrapped gas can soon render this casting a bad one.

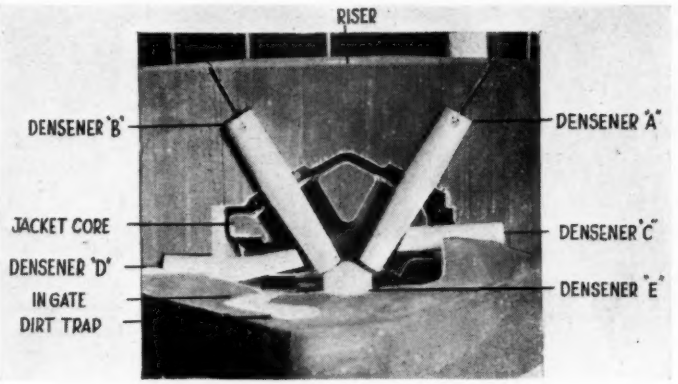

FIG. 2.—SHOWING POSITION OF DENSENERS.

Care should be taken also to ensure that the cores are a good fit to the prints, so as to prevent any possibilities of metal getting past and entering the vents. The mould having been closed, the runner basin was made up, and a cup was placed over the riser. This is a simple operation but nevertheless it is a very important one, for a runner basin badly placed, or not properly made, can spoil the results of many hours' work. This is still a point to which a great many moulders do not give sufficient attention.

Casting Condition

The casting was poured with clean hot metal from a hand shank, at a temperature of between 1,300 and 1,350 deg. C. The metal mixture used

Diagnosing a Cylinder Cover Casting—IV

was the cylinder iron normally used, giving a tensile strength of 16 tons minimum. The casting weighs approximately 46 lbs. and its composition was: T.C, 3.32; Gra.C, 2.5; Si, 1.33; Mn, 0.81; S, 0.12; and P, 0.38 per cent. The amount of steel in the charge was 10 per cent. When the casting had been made for some 10 min., preparations were made for withdrawing the denseners A, B, C and E (Fig. 2). The one at D had to be left in owing to its shape and was later drilled out. All these denseners were perfectly clean and had a dressing before inserting into the mould and were all slightly warmed up. They were easily withdrawn from the casting by the holes provided.

Dressings for chills vary from one foundry to another, but personal experience is that an even coating of plumbago, either rubbed on dry or painted on, forms a good dressing. Provided the densener is perfectly dry and clean when the dressing is applied there should not be much trouble in their use in dry sand work. As to the densener at E, it has been shown to be split vertically. This extra trouble was taken to ensure its easy removal, as it will be seen that it carries no taper.

DISCUSSION

MR. D. CARRICK asked if any trouble arose from metal fusing on to the denseners, and whether hard edges were formed where the denseners emerged from the casting.

MR. HAMMOND pointed out that prevention of the metal adhering to the denseners was a question of a suitable dressing and also dependent upon removal of the denseners from the casting before too long an interval of time which in the case of this casting was a maximum of 15 min. Hard places at the positions indicated by Mr. Carrick were a possibility, and to guard against these an extra machining allowance was made. This was ground off during fettling.

MR. L. E. SLATER was of the opinion that the machining allowances could be reduced, thereby tending to equalise the sections. He considered also that denseners were not the ideal solution to the problem, and indeed could not be employed if the casting was required to be produced on a quantity basis.

MR. J. KING also deprecated the use of denseners, pointing out that if they were used in green sand moulds, moisture was deposited on them. With dried sand moulds the same thing happened, although when eventually the moisture dried away a skin of oxide was left which caused a disturbance of the metal during casting.

MR. HAMMOND, in reply, remarked that the main denseners were not placed into the mould until after the drying process had been completed. They were warmed and carefully coated before insertion, thus avoiding the troubles described by Mr. King.

MR. GEO. HALL agreed with Mr. Slater that denseners must be ruled out for quantity production. He thought that Meehanite metal could be regarded as a different material from ordinary grey irons, and should not need denseners to make a sound job of the casting under consideration. Some years ago he had had experience in the production of castings from the Lanz Perlit hot mould process, and considered that the specimen casting could have been made satisfactorily by this means and without any denseners at all. This was another instance of the use of a special process or special materials such as could be employed where the numbers required were large. In Mr. Hammond's case it was a one or two off job, not warranting the use of special materials or processes, and under these conditions he thought he had proceeded along the right lines.

MR. L. TIBBENHAM expressed his appreciation of the thought and trouble taken by Mr. Hammond, Mr. Slater and Mr. King in presenting their solutions to the making of the specimen casting. As Mr. King had said, foundrymen should co-operate to the fullest extent, the benefit of so doing being mutual. He preferred the term "densener" to "chill" for the function fulfilled by metallic inserts as explained by Mr. Hammond. Chilling implied a more drastic action, and should be restricted for reference to cases where it was intended to develop a hard surface.

Finally MR. C. J. LAKE paid tribute to the speakers, who had contributed a most interesting and enlightening series of talks and discussions.

ARMASTEEL DISCUSSION

(*Continued from page* 38.)

Therefore, in using alloys they were used because either of these things were wanted or they were used to counteract these effects. Molybdenum, in comparison with chromium, was a mild carbide stabiliser and it would be necessary to increase the silicon content somewhat. Actually in these pearlitic malleables, alloys were not usually used because the improvement in properties generally was not considerable. They always had to be dealt with very carefully.

The meeting expressed its thanks to the author, and also to Mr. Peace for presenting the Paper. Mr. Peace, acknowledging, asked for written contributions to the discussion and promised that Mr. Joseph would reply to all the comments made on the Paper.

ARMASTEEL—ITS MANUFACTURE, CONTROL AND APPLICATIONS

PRESENTATION AND DISCUSSION OF A.F.A. EXCHANGE PAPER AT JUNE ANNUAL CONFERENCE OF INSTITUTE

MR. A. E. PEACE, introducing the Paper, said he was pleased to be privileged to present this Paper on behalf of Mr. Joseph, first because it was an American Exchange Paper, secondly because Carl F. Joseph was a distinguished malleable metallurgist and was associated with what he believed was the largest malleable iron foundry in the world, and thirdly, because it was the first Paper upon the subject of pearlitic malleable cast iron to be presented to the Institute. In the early part of the Paper Mr. Joseph drew attention to the need for increased technical control in the malleable industry, and pointed out that wartime conditions had stimulated consideration and investigation of materials to replace many steel and non-ferrous parts. The paragraph headed "Castings and Forgings" was of considerable importance, and was elaborated by illustrations and data which he would refer to later, although they were not in the printed Paper.

Derivation of Word "ArmaSteel"

Many would question the use of the word "steel" in describing this product, and Mr. Joseph's mention of a reference to it as graphitic steel. The trade name used had been built up from the Ar critical point and part of the word malleable, the word steel being used in reference to the matrix of the material which resembled spheroidised steel. The technical world, of course, would describe this material as a pearlitic malleable cast iron, and he believed he was right in saying that they drew a dividing line between steels and cast irons by the presence or otherwise of eutectic carbon, which gave a limit for steel at a maximum of around 1.70 per cent. The metal as cast was a white cast iron of composition similar to that of blackheart malleable. The heat-treatment was carried out in two stages, annealing over a period of around 15 hrs. at 950 deg. C., completing first stage graphitisation, the castings being cooled to about 870 deg. C., and then air- or oil-quenched. Second stage graphitisation was carried out by heat treatment at 675 deg. C. for a period of from 4 to 12 hrs., depending upon the physical requirements. The combined carbon remaining was such as to give properties comparing favourably with those of forgings in the 1,035-1,050 range. These numbers, and others used subsequently, referred to classification of steels under a numerical system designed by the American Society of Automotive Engineers. The first figure (1) signified plain carbon steel and the latter two figures indicated the carbon content, *e.g.*, 1,035 was a 0.35 per cent. carbon steel. Later numbers, 1,112 and 1,145, referred to what would be called free cutting steels of 0.12 and 0.45 per cent. carbon content. The steel later referred to as 5,040, was a carbon chrome steel.

The range of tensile properties obtainable in ArmaSteel was shown in Fig. 36, together with the Brinell hardness values. It might be of assistance if he gave some conversion of the lbs. per sq. in. to tons per sq. in., *e.g.*, 60,000 lbs./sq. in., was equivalent to 27 tons, and 100,000 lbs./sq. in. was equivalent to 45 tons. The yield ratios in this material at the bottom of the curves were approximately 74 per cent., increasing to 85 per cent. at the top of the curve.

Mr. Joseph considered that the raw materials going into the charge had more effect upon properties than the melting equipment used, and enlarged upon this in respect of pig-iron and cupola coke. His melting process was duplexing with cupola and electric furnace, and therefore a charge comprising high silicon pig-iron, steel scrap and re-melt was used. Chart No. 1 gave a schedule of the data collected at the blast furnace when the pig-iron was made, and it would be surprising to many to see the extent to which Mr. Joseph went in looking after his pig-iron supplies. The Paper stated that microscopical examination of the pig-iron was carried out as a routine test, and it then referred to annealing difficulty which has been encountered with metal made from pig-iron in which appreciable amounts of steadite were present. Mr. Joseph proceeded further to show the effect of graphite size in the pig-iron upon the size of the free carbon nodules produced in the finished material. Although Mr. Joseph only referred specifically to the effects of steadite and graphite size, he gave a hint that these were not the only features affecting the quality of the material.

Regarding control of the product, it would be seen that tests and inspection were carried out to a rather unusual degree for foundry work. Special tests had been devised for certain castings, and use was made of magnetic and electrical resistance testing in addition to pickling, hydraulic and hardness testing. Many of these types of inspection were carried out on castings to 100 per cent.

The Appendix

It was emphasised that the replacement of parts by new materials, which under present circumstances might be the outcome of necessity, could only be permanent upon the basis of engineering performance, availability of material and ultimate cost. In the Appendix, which will be published in the Proceedings, Mr. Joseph illustrated diesel engine pistons produced in this material for automobile work and for transcontinental trains, and reported performance on the latter up to 1,000,000 miles without failure. In assessing advantages of castings in this metal as compared with steel forgings, photographs and data were given, and Mr. Peace said he would just quote that in automobile transmission gears, and in an internal gear drum used presumably on front wheel drive vehicles, reductions in rough weight of castings against forgings are shown of 20, 30 and 11 per cent., and these reductions had resulted in 32, 51 and 25 per cent. less metal to be removed in machining. Numerous examples were given of crankshafts, camshafts, universal joint yokes, propeller shaft flanges, rocker arms and light parts which have replaced medium carbon steel forgings and case-hardening steels. Photo-

ArmaSteel—Its Manufacture, etc.

micrographs were shown giving the comparison between ArmaSteel and other metals, and the series of photo-micrographs for ArmaSteel covered material with a range of 140 to 300 Brinell, and tensile strengths of 25 to 45 tons per sq. in.

Attention was drawn to various properties such as machinability, damping, high yield ratio, non-seizing properties, fatigue strength and response to localised hardening. In connection with the last, it was shown that ArmaSteel has a high hardenability rating, and compared favourably with the 0.4 per cent. carbon chrome steel. Data upon the response to hardening were given in Fig. 35, and the curves extended over a range of 200 Brinell up to 575.

In conclusion, Mr. Joseph gave a list of advantages claimed for ArmaSteel castings, and drew attention thereby to the fact that tensile strength, which was so popularly used as the evaluation of a material, was frequently of less importance than many other properties which were not so commonly referred to. Mr. Peace particularly mentioned point (2), which applied generally to castings in all metals. By comparison with forgings, it was a paramount advantage that in a casting it was possible to obtain the metal distributed where it would do the most good, giving maximum strength with minimum weight. This entailed great attention to design, and great endeavours on the part of the foundrymen to produce more accurately to dimensions.

DISCUSSION

MR. G. R. WEBSTER asked if it were possible to have further details of the furnace equipment used in connection with the manufacture of ArmaSteel.

MR. PEACE said that unfortunately this Paper had only recently arrived in this country and it had been impossible for him to correspond with Mr. Joseph on matters upon which further information might be required. However, a note would be made of the request of Mr. Webster and Mr. Joseph would be asked to elaborate in his written reply to the discussion.

The CHAIRMAN (Mr. D. Sharp) said the furnaces were almost a duplicate of those used by the Ford Company at Dagenham.

Compositional Ranges

MR. T. R. TWIGGER commented on the use of the term "white cast iron" in the Paper and expressed the hope that when more leisurely days came again the Technical Committee would have on its agenda once more the question of nomenclature, although not as an item which in the past had always been carried forward to the next meeting.

Continuing, he said the Paper illustrated a very interesting material and one point of considerable importance was whether there was any advantage in doing the oil hardening and tempering during the heat-treatment cycle. He had in mind that where a high degree of hardness finish was required it might be more profitable to fully-anneal and then re-harden. Again, more information was wanted with regard to the possible range of analysis. One definite composition only was mentioned and it was easy to imagine that the silicon content would have a very potent effect on the hardness and test figures. If Mr. Peace could obtain more information with regard to this, it would be valuable. He would also be very interested to have particulars concerning the effect of the alloy additions, particularly molybdenum, because he believed that in this way extremely useful properties could be given to the material.

Finally, with regard to the possible applications of this material, it seemed more likely that it would replace steel, particularly forged steel, and he did not think the case for the replacement of aluminium was particularly good, even with the present short supply.

MR. PEACE said he was very pleased to have had this contribution to the discussion as it had opened up some aspects which perhaps he had not dealt with adequately in presenting the Paper. In the first place, there might be some doubt as to what was pearlitic malleable and why it was so called. The answer was that in blackheart malleable it was only possible to produce a product which finally had a structure of ferrite and free carbon in nodular form. That had been the accepted type of blackheart malleable for years. Pearlitic malleable referred to a somewhat similar material but instead of a ferrite matrix there was a matrix which was composed of pearlite or any other of the transition stages from martensite downwards.

With regard to hardening as a separate operation, it should be mentioned that this was only one type of pearlitic malleable that was produced. Actually there were well over a dozen different types. Pearlitic malleable was produced by different people in different ways and it was just that they had their own fancy ideas how to do it. He himself had been producing pearlitic malleable for 10 years and in his case he carried out what was the normal blackheart annealing treatment and re-heated the material before hardening, which was what Mr. Twigger had suggested.

Variations in Composition

As to variation in composition, the important thing to remember was that a metal was being cast which must not show any primary graphite in the "as cast" state. Therefore, it was necessary that the carbon, silicon, manganese and sulphur ratios must be such as would not favour primary graphitisation. His own work was as near the borderline as possible, which necessitated that there should be very little latitude in the composition. As regards carbon content, however, one would not work to a greater variation than, perhaps, a total range of 0.40 per cent., but in silicon content much closer than that. In Mr. Joseph's case he believed the silicon content was between 1.3 and 1.4. In manganese there might be a range of 0.05 per cent., and perhaps sulphur would be 0.02 per cent.

Concerning alloy additions, these fell mainly into two classes, *viz.*, those alloys which favoured graphitisation, and those which stabilised the carbide.

(*Continued on page* 36.)

SKELETON PATTERNS

BY "CHECKER"

Valuable time can be saved in the patternshop by making skeleton patterns for castings, where only a small number are required, and when the extra time absorbed in the foundry on this class of work has been taken into account, it will be found that the all-round saving in hours is considerable, which gives quicker delivery of the castings to the machine-shop.

A skeleton pipe for which only three castings were required was made in the following way:—The pattern was made in halves and dowelled together, a plate for each half being made out of 1-in. pine and cut to shape, three pieces of wood being used with

FIG.1.

FIG.2.

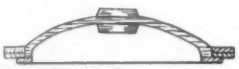

FIG.3.

FIG.5.

FIG.6.

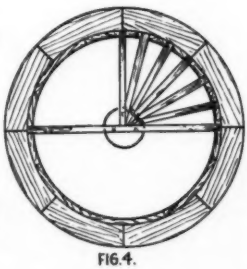

FIG.4.

battens screwed on to hold them to shape, as shown in Fig. 1. The flanges were checked over the plate and screwed on, the prints being added later and fastened to the flanges. Pieces of wood from 1-in. pine were made to the correct shape of the pipe and screwed on about 3 in. apart, as shown in Fig. 2. It will be noted that where the three branches meet a solid piece was made to ensure the correct shape being cast. The edges of the plate were worked to the shapes which then completed the skeleton pattern. Half a corebox was made, the diameters being cut out on the pattern milling machine.

A skeleton pattern was also requested for a cover; for this the complete flange was made first with two rows of segments, the outside and inside diameters being finished on the sandpaper disc and bobbin. Another row of segments, finished to size, was added for the spigot. It should be noted that the inside diameter of the flange was made larger than required for the casting, so that when the spigot was fastened on, a step for the radial pieces to rest on was formed, as shown in Fig. 3. The dome was formed by making one full piece correct shape for the centre, with a flat each side to take the centre boss, when this centre-piece was fastened to the flange and the inside centre boss added, a ledge was formed for the shaped pieces to rest on and the pieces were screwed into the boss, Fig. 4. The radial pieces were marked off from a template to correct size, and had the centre boss diameter line marked on for a guide so that they could be positioned correctly, as is shown in Fig. 5. It was necessary to taper these radial pieces near the centre to fit them in owing to the difference in diameters between the centre boss and flange. The top part of the centre boss was added last. Fig. 6 shows the completed pattern.

NATURAL CORROSION PROTECTION ON WATER MAINS

In the course of an investigation of corrosion in water mains, H. HAUPT, as reported in "Jahrb. vom Wasser XIV," found that a number of waters, which, from their composition, should have resulted in marked corrosion effects, yet did not produce any of these effects in the mains through which they flowed. The absence of these effects was due to the production of a protective coating. The waters in question were very soft, low-saline varieties with *p*H values between 5.85 and 7; carbonate hardness 0.6 to 3.1 deg.; free CO_2 15 to 46 mg. per l. Analysis of the protective coatings showed that one was composed of CaO, Al and Fe and 0.52 per cent. phosphoric acid in iron pipes and 0.81 per cent. in lead pipes. It was noted that the phosphate in the waters was very low, although higher than in most waters, *viz.*, 0.02 to 0.23 mg. P_2O_5 per l. This concentration yet seems to be sufficient for the formation of the phosphate and ferruginous deposits found, provided the water contains a small amount of iron. The iron required is very low, and may be taken up from the pipes when first put into service. It appears that the formation of the deposits is due to the very low solubility of the readily-formed double salts of phosphoric acid, such as Fe-Al and Fe-Ca phosphates, which are much less soluble than the already barely soluble phosphates of Fe, Al and Ca. Colloidal processes obviously play some part in the formation of the coating, particularly the exceptionally high concentration of silica in the waters in question (15 to 20 per cent. of the dry residue). From his investigations, the author concludes that phosphate-bearing water is always liable to form a protective coating, if it contains a little Fe or can take up some of the metal from the mains themselves. A sufficient quantity of lime for the formation of the deposit is present in even the softest waters.

RAILINGS SURROUNDING the grounds of the Northern Ireland Parliament Buildings in Belfast, representing hundreds of tons of metal, are to be converted into war weapons.

CRACK DETECTION IN CASTINGS

Recently our representative inspected a new and extremely promising process for the inspection of castings liable to exhibit cracks. The system consists in dipping the articles to be tested in a bath maintained at *circa* 75 deg. C. by a thermostat. This bath contains a solution which carries fluorescing and degreasing salts. The solution enters any crack to the extent of several molecules. After sufficient time has elapsed to raise the material—ferrous or non-ferrous—to approximately bath temperature the components are immersed in a second cold bath which washes off the fluorescent salts except for those remaining in the cracks. Then the components are placed under an ultra-violet ray light which illuminates very brilliantly any cracks, because there is an aggregation of fluorescent crystals in the cracks. For light alloy work the "Glo-Crack" system, as it is called, is distinctly superior to anodising because the latter process is prone to show up as cracks what are in reality only slight surface roughnesses. A crack to warrant the application must be deeper than it is wide, which differentiates it from a scratch. The firm responsible for the creation and selling of this system is Colloidal Research Laboratories, Limited, 60-70, Petty France, London, S.W.1.

NEW PATENTS

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each.

545,831 PARKER, A. LA R. Rod or pipe bending machines.

545,911 JAHN, A. R. Production of granules or coarse powder of aluminium.

545,938 WILLIAMS, W. P. (Armco International Corporation). Method of producing silicon steel sheet or strip.

545,965 UDY, M. J. Chromium recovery.

545,972 WOOD & COMPANY, LIMITED, H., and BRITTON, W. Pipe joints.

546,003 GREENAWALT, J. E. Screening sinter and collecting dust in connection with sintering machines.

546,020 FASSOTTE, P. C., and COLCLOUGH, T. P. Manufacture of steel.

546,039 OPEN HEARTH COMBUSTION COMPANY. Open-hearth furnaces.

546,104 MADARAS, J. D. Process and apparatus for reducing divided material such as ores containing solid oxides with reducing gas.

546,131 BIRMINGHAM ELECTRIC FURNACES, LIMITED, and KERFOOT, F. Furnace hearths.

546,155 PLASCO, LIMITED. Machine for forming and trimming die castings.

546,164 TATE, C. E., and DAVY & UNITED ENGINEERING COMPANY, LIMITED. Universal coupling for reversing and continuously running torque transmission for rolling-mill drives and the like.

PLANS FOR SCOTTISH INDUSTRY

IMMEDIATE AND POST-WAR SECURITY

The Scottish Council of Industry has prepared submissions for the consideration of the Secretary of State for Scotland (Mr. Thomas Johnston) designed with the object of securing the immediate and post-war economic security of Scotland. The main points in the submissions deal with the transfer of labour, the concentration of industry, storage facilities, specific industries, and the post-war situation, and consideration of these matters was given at a meeting of the Executive Committee of the Council at Glasgow.

It is stated that there still exists in Scotland a considerable pool of non-mobile labour available for employment, and in certain industries much productive capacity which could be usefully employed. These facts have already been brought to the attention of the Production Ministers, in order that Scotland may receive her due share in industrial developments. The Council greatly regret the necessity for transferring young workers from Scotland to England. They entirely recognise that labour must be found for the staffing of the great war factories—if necessary at the expense of industries engaged on less essential work—but they feel that, once labour is moved, it is difficult to effect its return. When schemes of concentration are under consideration, there is every reason for providing a lower ration of concentration in Scotland than in England. The Council suggest, as a principle, that no Scottish industry should be concentrated to the extent that that industry is extinguished in Scotland altogether. The Council express pleasure at the fact that the Ministry of Supply and the other production departments are giving active assistance in placing further work in Scotland.

With regard to the post-war situation of Scottish industry, and on account particularly of lack of industrial estate facilities in Scotland relatively to England, the Council suggest that in connection with any new building for production or storage which may be undertaken, consideration should be given to its location and suitability from the standpoint of post-war needs. Camps and training establishments should be designed with a post-war significance.

At the close of the Executive Committee meeting Sir Steven Bilsland reported that the British Ironfounders' Association had put forward difficulties they had experienced in obtaining a share of munition orders. The Association would submit a further memorandum to the Council.

THE GOVERNMENT of Southern Rhodesia has agreed to pay £200,000 as the purchase price of the Rhodesian Iron & Steel Corporation's undertaking, now under State control, together with an amount equal to excess profits tax and income tax on the revenues and profit of the Corporation at August 1. This figure should give each shareholder £2 a share, which is a compromise between the Government's estimate of 30s. as the value of a share and the Corporation's estimate of £3.

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IS CHARACTERISED by closeness of grain structure, uniformity of composition and fine graphitic carbon evenly distributed.

IS PRODUCED to guaranteed analysis in seven standard grades.

CAN BE MADE to customers' individual requirements with total carbon from 2·6 per cent. upwards.

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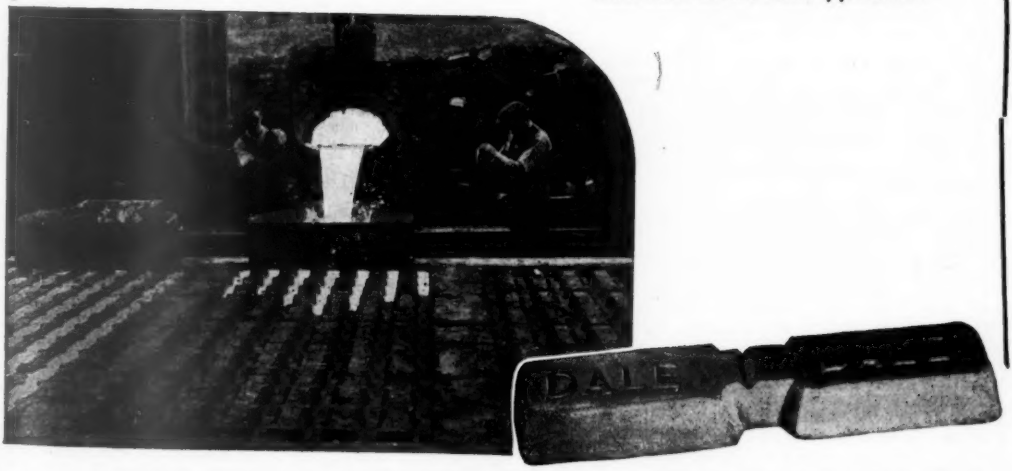


THE STANTON IRONWORKS COMPANY LIMITED, NEAR NOTTINGHAM

NEWS IN BRIEF

THE CLAIM for higher rates of pay for women engaged in the engineering industry will be discussed by the unions and employers on September 23.

SCHOOLS FOR managing directors and managers were among cures for mass unemployment after the war suggested by Mr. B. Seebohm Rowntree at Ipswich on Monday.

A MEETING of the creditors of the Whitehaven Hematite Iron & Steel Company, Limited, will be held at the offices of the North Lonsdale Iron & Steel Company, Limited, North Lonsdale Road, Ulverston, on September 11.

THE BELFAST TOWN COUNCIL invites tenders by October 9 for the supply and erection of two water-tube boilers, feed pump, feed-water heater, pipe work, etc. Further details may be had from The Engineer, Gasworks, Ormeau Road, Belfast.

ERIE FOUNDRY COMPANY, well known for its heavy foundry products, is going out of the foundry business and will henceforth conduct a general machine shop business. Work has been started on construction of a new $2,500,000 plant in Erie, Pa.

AN OFFER TO SHAREHOLDERS of 75,000 5s. ordinary shares at 21s. each is being made by Carrier Engineering Company, Limited. The issue is being made for the purpose of redeeming at 21s. each the 75,000 £1 second 5 per cent. redeemable cumulative preference shares.

A BALLOT of members of the Amalgamated Engineering Union has shown a majority in favour of admitting women to the union. An alteration of the rules will have to be made. In the past the A.E.U. has always strongly resisted women membership, but the entry of many thousands of women into war factories has changed the situation.

THE ADDRESS of the Wrought Light Alloys Development Association is now Union Chambers, 63, Temple Row, Birmingham, 2. The registered office of the Association remains at 25, Bennett's Hill, Birmingham, 2, to which address all communications for the secretary should be forwarded. The telegraphic address has been changed from "Wroughtal" to "Lightaldev, Birmingham."

THE MINISTRY OF SUPPLY has made an offer to purchase the Monk Bridge Iron & Steel Company, Limited, at a figure which, after payment of all outstanding liabilities of the company and the costs of liquidation, would leave a sum sufficient to pay 15s. per share to the preference shareholders, which figure the preference shareholders have agreed to accept, and 2s. 6d. per share to the ordinary shareholders. Negotiations were opened up some time ago when the Ministry of Supply, in order to facilitate expansion, approached the directors with a view to taking over the undertaking under the Emergency Powers (Defence) General Regulations. An extraordinary general meeting of the company is called for September 15 to pass a special resolution for the voluntary winding up of the company.

PERSONAL

MR. C. E. BELL has been appointed assistant secretary of the Crucible Steel Makers' Association.

MR. ALAN GREIG, previously assistant secretary, has been appointed secretary of the Blyth Dry Docks & Shipbuilding Company, Limited.

MAJOR PETER LAIRD, son of Mr. J. W. P. Laird, director of Cammell, Laird & Company, Limited, who was reported missing in the Middle East in July, is now known to be a prisoner of war in Italy.

MR. JAMES WILSON, reputed to be the oldest brass-founder in the North of Scotland, has retired. He has worked at his trade in Elgin for 70 years. Now, at the age of 84, he has closed his business owing to scarcity of material.

COMMANDER E. R. MICKLEM, a director of Vickers-Armstrongs, Limited, has been released by the company to be chairman of the Armoured Fighting Vehicles Division and chairman of the Tank Board of the Ministry of Supply.

MR. JOSEPH HEPWORTH, M.P. for East Bradford, past-President of the Institute of British Foundrymen and of the West Yorkshire Branch, is reported to be progressing satisfactorily following a second operation: he has been suffering from concussion as a result of a fall.

MR. T. GODDARD MANDER, a Sheffield solicitor, who is secretary of several steel trade manufacturers' organisations, has been appointed chairman of the Sheffield District Rollers' and Tilters' Association, of which he was formerly secretary. Mr. C. Woodcock succeeds him as secretary.

MR. RICHARD MATHER, who has been appointed a director of Pease & Partners, Limited, pig-iron makers, colliery owners, etc., Darlington, is a director and chairman of the Skinningrove Iron Company, Limited. He was formerly technical director to the Tata Iron & Steel Company, Limited.

Wills

HESKETH, E., late chairman of J. & E. Hall, engineers and ironfounders, Dartford	£48,764
HEPWORTH, G. E., joint managing director of Hepworth & Grandage, Limited, piston manufacturers, Bradford	£33,417

NEW TRADE MARKS

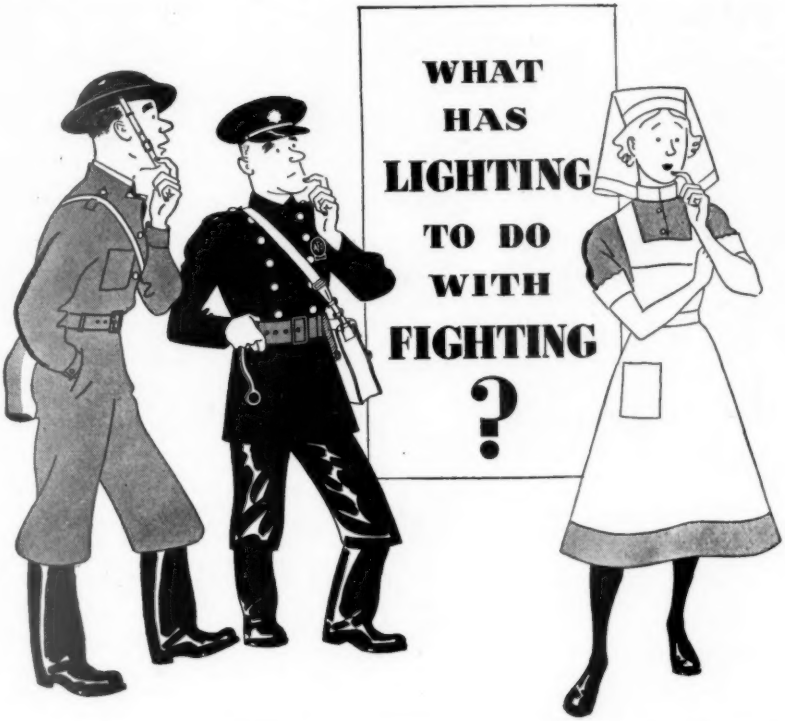
The following applications to register trade marks appear in the "Trade Marks Journal":—

"PASSAG"—Metals. Capper Pass & Son, Limited, Mill Lane, Bristol.

"FARRAR"—Boilers. Farrar Boilerworks, Limited, The Spitals, Northgate, Newark-on-Trent, Notts.

"NABIVE"—Tools for use in machine tools. Watson, Saville & Company, Limited, Mowbray Street, Sheffield, 3.

"INTEGRITY" — Earth-working and earth-carrying machines, boilers, hydraulic machinery, machine tools, power-driven tools, etc. John A. Grey & Partners, Limited, Bush House, Aldwych, London, W.C.2.



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COMPANY NEWS

(Figures for previous year in brackets.)

Steel & Company—Ordinary dividend of 7½% (6%).

Cammell Laird—Interim ordinary dividend of 4% actual (2.4d. per 5s. unit), less tax (same).

Hardypick—Profit for the year to June 30, 1942, after all charges and including £912 profit on sales of investments, £4,982 (£2,409); ordinary dividend of 10% (same); forward, £6,564 (£6,131).

Hartley & Sugden—Net profit for the year ended June 30, £14,591 (£4,806); brought in, £887; to taxation, £9,000 (£600); preference dividend, £1,661 (same); dividend of 6% (5%) on ordinary shares, £3,060 (£2,550); forward, £1,757 (£887).

Rippingilles—Profit for the year to March 31 last, £13,546; to taxation, £7,484; war damage insurance, £201; goodwill written off, £2,500; brought in, £5,335; preference dividend for the year to December 31 last, £1,500; dividend of 6% on the ordinary shares; forward, £5,246.

Metal Industries—Net profit for the year to March 31 last, £179,684 (£162,375); income-tax and N.D.C., £85,678 (£72,632); dividend on the 5% preference stock, £12,760 (£14,688); dividend on the "A" and "B" ordinary stocks of 5% (same); to buildings and plant reserve, £4,588; forward, £126,283 (£107,277).

Sheffield Steel Products—Trading profit for the year to March 31, after taxation, £75,147 (£75,313); brought in, £12,185 (£5,922); ordinary dividend of 5% (same); to depreciation, £25,600 (£25,000); provision to A.R.P., £1,013 (nil); to additional debenture sinking fund, £2,326 (same); to general reserve, £10,000 (same); forward, £17,565.

Electric Furnace—Net profit for the year ended March 31, £50,821 (£47,662); dividends receivable from subsidiary companies, £4,240 (nil); brought in, £6,961; dividends on preferred ordinary and ordinary shares, £13,100; second interim dividend of 4½%, making 8% (same) on both classes; to E.P.T. and income-tax on current profits, £28,000 (£31,000); to general reserve, £10,991 (nil); forward, £6,681 (£3,711 after directors' remuneration).

CANADIAN PIG-IRON production for the first quarter of 1942 attained the all-time record of 474,245 net tons, a gain of 60 per cent. over the 296,288 tons reported for the same period a year ago. Production for March was a record of 167,116 tons compared to 143,973 tons in February, 1942, and 102,038 tons in March, 1941. Production of steel ingots and direct steel castings totalled 807,840 net tons for the first quarter, 45.68 per cent. above the 554,482 tons reported for the corresponding period of last year. March production of steel ingots and castings was 265,903 net tons compared to 242,921 tons in February, 1942, and 218,939 tons in March, 1941. During March, steel furnaces in Canada operated at 98 per cent. of capacity, blast furnaces at 96 per cent. As in February, 10 out of a total of 11 furnaces in Canada were in blast.

OBITUARY

MR. GEORGE EXTON TAYLOR, who for 43 years was with Mather & Platt, Limited, died at Southport recently, in his 83rd year.

MR. GRANVILLE WOOD, of the firm of A. Wood & Son, engineers and machinists, of Stubbins, Ramsbottom, Manchester, died recently.

MR. WILLIAM WHITEHOUSE, head of the old-established firm of W. Whitehouse & Sons (Halesowen), Limited, brass and iron founders, died recently, aged 73.

WE REGRET to announce the death of Mr. N. McManus, M.B.E., manager of the Argus Foundry, Thornliebank, Glasgow. He was well-known in foundry circles, having presided over the Scottish Branch of the Institute of British Foundrymen a few years ago.

MR. ROBERT HAMILTON, a well-known figure in the Scottish pig-iron industry, died at Giffnock, Glasgow, recently. He was a member of the West of Scotland Iron and Steel Institute, of which he was at one time president, and served as chairman of the West of Scotland Section of the Society of Chemical Industry. He joined the firm of R. & J. Dempster, Limited, of Manchester, who had acquired interests in Scotland in connection with the treatment of blast-furnace gases, and he was appointed to take charge of the works erected by the firm of Shotts. Later he was transferred to a similar works erected by the company at Glengarnock, Ayrshire. While at Glengarnock he joined the service of Colvilles, Limited, and was in charge of the ironworks and by-products plant. From Glengarnock Ironworks he returned to the service of R. & J. Dempster, Limited, at Langloan Ironworks, Coatbridge, where he remained until he retired from business. Mr. Hamilton was the author of several Papers on blast-furnace gas.

NEW COMPANIES

("Limited" is understood. Figures indicate capital. Names are of directors unless otherwise stated. Information compiled by Jordan & Sons, 116, Chancery Lane, London, W.C.2.)

Bastwick Metals, 110, Bishopsgate, London, E.C.2—£2,000. F. T. Barnes and A. Pinner.

James Oakes (Engineering)—£2,000. G. D. Cotton, 34, Park Road, London, W.4, subscriber.

Bintcliffe Turner, 9A, London Road, Sevenoaks, Kent—Toolmakers, engineers, etc. £1,000. E. D. Bintcliffe and V. J. Turner.

Namloc (Engineering), 31, Temple Row, Birmingham—£1,000. P. S. Gardner, 199, Wolverhampton Street, Dudley, subscriber.

NOTES FROM THE BRANCHES

London—Mr. John Gardom, the well-known foundry consultant, is to address a meeting of the London Branch at 7 p.m. on September 17, at the National Liberal Club on the "Wartime Work of the Technical Committee."

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G.P.159

Raw Material Markets

IRON AND STEEL

Demand for foundry iron from the light-castings section of the industry is easily satisfied. Consumers in this category are interested mainly in high-phosphorus iron, which is made from ores found in the United Kingdom, and ample supplies are available to meet the needs of all comers. Some users have, in fact, accumulated quite substantial stocks of this material. Many makers of light castings are likely to be affected by the concentration proposals in the foundry trade, so that in a number of cases they are buying only their immediate requirements of iron. Business in light castings remains somewhat subdued, as very few makers are receiving much in the way of Government orders and other outlets have been severely restricted.

In the heavy engineering branch of the foundry trade, works are in full operation, mostly on contracts for the various Government departments. On the whole, supplies of raw materials are also reaching these users satisfactorily, but they have had to make certain adjustments in their mixtures to meet prevailing conditions. Hematite, for example, is very difficult to acquire and is strictly controlled, the authorities keeping this material for priority consumers who are unable to make use of alternative descriptions of iron. Low-phosphorus iron, too, is not easy to obtain in large tonnages, but sufficient is forthcoming to satisfy urgent needs. Heavy engineers are utilising considerable quantities of high-phosphorus iron, refined iron, and steel scrap, so that they are able to maintain full-scale operations at their works.

Supplies of foundry coke continue to be delivered satisfactorily, stocks at many consuming points having been built up to a useful level. For delivery to Birmingham and Black Country stations, the current price of Durham best foundry coke is 69s. 3d. per ton. This quotation is officially controlled, so that all contracts are subject to a rise-and-fall clause which protects both buyer and seller against fluctuations.

The steelworks are in possession of full order-books and they are coping with the large volume of business very satisfactorily. There is particular pressure for the special and alloy grades of steel, these materials being used extensively by aircraft, armament and munition works, etc. Consequently, everything possible is being done to ensure that production is raised to maximum levels and much has been accomplished in this direction. Activity in other branches of the steel industry is maintained.

NON-FERROUS METALS

The copper supply situation appears to be very healthy. No details as to stocks or arrivals are, of course, issued for publication, but it is evident that there are ample tonnages available to consumers engaged on important orders associated with the war effort. There is not likely to be any relaxation of the strict conditions governing distribution of the red metal, as the authorities are wisely pursuing a policy whereby no extravagant use of copper is permitted, the needs of the future being taken into account.

According to American sources, tin from the smelter at Texas City which has been shipped to consumers has been found satisfactory. Some 1,500 tons a month, it is stated, has so far been produced. The War Production Board has announced that the smelter is capable of producing 74,000 tons per annum of high-grade metal, the 1942 output being in the region of 40,000 tons, as the smelter did not commence operations until April. Tin trade circles have been somewhat surprised by the W.P.B. figures, as it was not thought that the smelter was capable of producing quite such a large tonnage.

Labour shortage remains a paramount difficulty at the Bolivian tin mines, and is the chief reason for believing that production this year is unlikely to exceed that of 1941 by any appreciable margin. Last year the output was 43,000 tons of fine tin. There have been many statements to the effect that production could be stepped up by the development of the use of machinery at the mines, but advices from those more familiar with the Bolivian mines indicate that opportunities in this direction at the present time are very restricted. The price basis on which Bolivian tin producers are now operating is considerably higher than it was during the earlier part of the year, so that there is every incentive for raising the maximum tonnage of metal, but until more adequate supplies of labour become available, any expansion must inevitably be of slight consequence. The latest export figures of Bolivian tin—in respect of the month of May last—are rather disappointing. In that month 2,864 metric tons was exported, compared with 3,244 tons in April and 3,587 tons in May, 1941. The Banco Minero de Bolivia, commenting on the May results, affirms that, although one cannot take the output of a short period as a basis for estimating the possible total exports for 1942, in view of the May figures, "unless the next few months register a substantial increase, it will be very difficult to attain the 1941 export level." A further announcement from the Banco Minero de Bolivia states that North American capital has recently become interested in various medium-sized mines in Bolivia, particularly tin and tin-wolfram, and that the interested parties are hoping to secure a very considerable increase in production.

DURING 1941, net earnings of the American steel industry amounted to approximately 6.2 cents on each dollar of the largest sales volume ever recorded in the industry. Although sales last year increased over 1940 by over 50 per cent., earnings per dollar of sales declined 23 per cent. Total sales for the industry in 1941 are estimated at $5,260 million, compared with $3,489 million in 1940 and a previous peak of $3,800 million in 1918. In 1941 the industry's profit of 6.2 cents on each dollar of sales compared with 8.1 cents in 1940.

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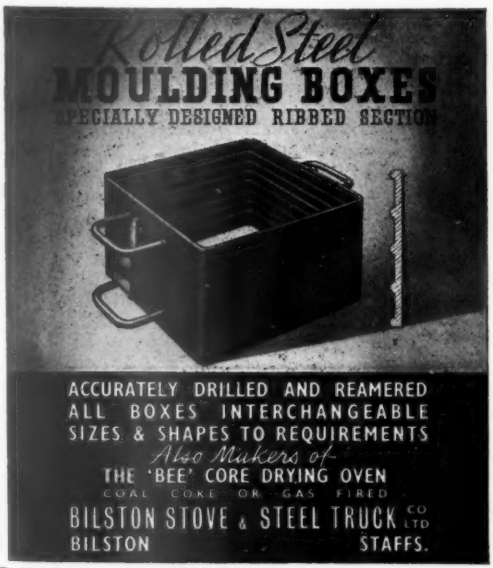

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COUNCIL OF IRONFOUNDRY ASSOCIATIONS

Chairman : FitzHerbert Wright, The Butterley Company, Ripley near Derby. Secretary : V. Delport, 2, Caxton Street, Westminster, S.W.1.

Participating Associations : British Bath Manufacturers' Association ; British Ironfounders' Association ; British Malleable Tube Fittings Association; Cast Iron Axlebox Association ; Cast Iron Chair Association; Cast Iron Heating, Boiler and Radiator Manufacturers' Association; Cast Iron Segment Association ; Greensand Pipe Founders Association of Scotland; Ironfounders' National Confederation ; National Association of Malleable Ironfounders ; National Ingot Mould Association ; National Ironfounding Employers' Association; Agricultural Engineers' Association (affiliated) ; British Cast Iron Research Association (affiliated); British Grit Association (affiliated); Institute of British Foundrymen (affiliated).

INSTITUTE OF BRITISH FOUNDRYMEN

PRESIDENT, 1941-42 : Major R. Miles, M.Eng. Head Wrightson & Company, Limited, Thornaby-on-Tees.

LIST OF SECRETARIES—

General Secretary : T. Makemson. Acting Secretary, J. Bolton Saint John Street Chambers, Deansgate, Manchester 3.

BRANCHES

Birmingham, Coventry and West Midlands : A. A. Timmins, F.I.C., 21-23, St. Paul's Square, Birmingham, 3. E. Midlands : S. A. Horton, "Three," Mostyn Avenue, Littleover, Derby. Lancs : H. Buckley, Ellesmere, Norfolk Avenue, Burnley. London : V. C. Faulkner, 3, Amersham Road, High Wycombe. Middlesbrough (*pro tem.*) : J. K. Smithson, North-Eastern Iron Refining Company, Limited, Stillington, Stockton-on-Tees. Newcastle-upon-Tyne : C. Lashly, Sir W. G. Armstrong, Whitworth & Co. (Ironfounders), Ltd., Close Works, Gateshead. Scottish : J. Bell, 60, St. Enoch Square, Glasgow. Sheffield : W. Webb, B.Sc., 20, Brookfield Avenue, Mexborough, Yorks. Wales and Monmouth : A. S. Wall, 14, Palace Avenue, Llandaff, Cardiff. West Riding : S. W. Wise, 110, Pullan Avenue, Eccleshill, Bradford. South Africa : F. C. Williams, Mutual Building, Johannesburg.

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